

Patent Claims

1. A wet acid etchant for wet acid etching of intrinsic, n-doped or p-doped $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ with $0 < x < 1$, $0 < y < 1$, $0 \leq z < 1$ and $0 < x + z < 1$, comprising:
 - a) organic acid;
 - 5 b) oxidizing agent; and
 - c) hydrofluoric acid.
2. The wet acid etchant according to claim 1, wherein the organic acid is neat or a mixture.
3. The wet acid etchant according to claim 1, wherein the organic acid is
10 selected from citric acid, lactic acid, acetic acid and tartaric acid.
4. The wet acid etchant according to claim 1, wherein when $z = 0$, the organic acid is selected from citric acid, lactic acid and acetic acid.
5. The wet acid etchant according to claim 1, wherein the oxidizing agent is hydrogen peroxide (H_2O_2).
- 15 6. The wet acid etchant according to claim 1, wherein the oxidizing agent is an oxide-forming chemical, e.g. NaOCl or Ozone.
7. The wet acid etchant according to claim 1, wherein the wet etchant comprises:
 - a) up to 90 wt-% of organic acid,
 - 20 b) up to 50 wt-% of oxidizing agent; and
 - c) up to 25 wt-% of hydrofluoric acid,all wt-% are based on the total weight of the composition, the balance is made up by a solvent, preferably water.
8. The wet acid etchant according to claim 6, wherein the wet acid etchant
25 comprises:
 - a) up to 75 wt-% of organic acid,
 - b) up to 25 wt-% of oxidizing agent; and
 - c) up to 15 wt-% of hydrofluoric acid,

all wt-% are based on the total weight of the composition, the balance is made up by a solvent, preferably water.

9. The wet acid etchant according to claim 6, wherein the wet acid etchant comprises:

- 5 a) up to 60 wt-% of organic acid,
 b) up to 15 wt-% of oxidizing agent; and
 c) up to 10 wt-% of hydrofluoric acid,

all wt-% are based on the total weight of the composition, the balance is made up by a solvent, preferably water.

10 10. A process for wet acid etching of intrinsic, n-doped or p-doped $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ with $0 < x < 1$, $0 < y < 1$, $0 \leq z < 1$ and $0 < x+z < 1$, comprising contacting an $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ material with a wet acid etchant comprising:

- a) organic acid;
 b) oxidizing agent, and
15 c) hydrofluoric acid.

11. The process according to claim 10, wherein the organic acid is neat or a mixture.

12. The process according to claim 10, wherein the organic acid is selected from citric acid, lactic acid, acetic acid and tartaric acid.

20 13. The process according to claim 10, wherein when $z = 0$, the organic acid is selected from citric acid, lactic acid and acetic acid.

14. The process according to claim 10, wherein the oxidizing agent is hydrogen peroxide (H_2O_2).

25 15. The process according to claim 10, wherein the oxidizing agent is an oxide-forming chemical, e.g. NaOCl or Ozone.

16. The process according to claim 10, wherein the wet etchant comprises:

- a) up to 90 wt-% of organic acid,
 b) up to 50 wt-% of oxidizing agent; and
 c) up to 25 wt-% of hydrofluoric acid,

all wt-% are based on the total weight of the composition, the balance is made up by a solvent, preferably water.

17. The process according to claim 10, wherein the wet acid etchant comprises:

- a) up to 75 wt-% of organic acid,
- 5 b) up to 25 wt-% of oxidizing agent; and
- c) up to 15 wt-% of hydrofluoric acid,

all wt-% are based on the total weight of the composition, the balance is made up by a solvent, preferably water.

18. The process according to claim 10, wherein the wet acid etchant comprises:

- 10 a) up to 60 wt-% of organic acid,
- b) up to 15 wt-% of oxidizing agent; and
- c) up to 10 wt-% of hydrofluoric acid,

all wt-% are based on the total weight of the composition, the balance is made up by a solvent, preferably water.

15 19. The process according to claim 10, wherein the $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ semiconductor surface or structure is patterned with a masking layer prior to the contact with the etchant.

20. The process according to claim 19, wherein the masking material is selected from a photo resist, oxides, nitrides, carbides, diamond-film,
20 semiconductors or metals.

21. The process according to claim 19, wherein one or more cap layer(s) is (are) applied on the $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ semiconductor surface or structure so that patterning of said semiconductor is achieved without any reaction at the interface between the surface of the $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ semiconductor and the
25 masking material.

22. The process according to claim 21, wherein the cap layer is GaSb, InSb, GaAs, InAs, GaInSb, GaInAs, InAsSb, GaAsSb, GaInAsSb or other non-oxidizing material.

23. The process according to claim 10 wherein the $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ semiconductor surface or structure is exposed to H_2O_2 , and the organic acid and hydrofluoric acid in a two step manner.
24. A semiconductor structure prepared by wet acid etching of
5 $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ with $0 < x < 1$, $0 < y < 1$, $0 \leq z < 1$ and $0 < x + z < 1$, by contacting a semiconductor comprising $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ material with a wet acid etchant comprising:
- a) organic acid;
 - b) oxidizing agent; and
 - 10 c) hydrofluoric acid.
25. A semiconductor structure according to claim 24 wherein the the whole or parts of the $\text{Al}_{1-x-z}\text{Ga}_x\text{In}_z\text{As}_{1-y}\text{Sb}_y$ semiconductor material(s) the structure is composed of, is n-doped with Tellurium or other n-dopant, or p-doped with Beryllium or other p-dopant.
- 15 26. The semiconductor structure according to claim 25 wherein the etched material is part of a laser, Light-Emitting-Diode(LED), photodetector or optical waveguide structure.
27. The semiconductor structure according to claim 25 wherein the laser or optical waveguide structure is a ridge.
- 20 28. The semiconductor according to claim 26 or 27 wherein the laser is a Fabry Perot laser, Distributed Feedback/Reflector Laser (DFB/DBR) or Interferometric laser (as Y-laser or alike).
29. The semiconductor according to claim 26 wherein the etched material is part of a Vertical-Cavity Surface-Emitting Laser (VCSEL).
- 25 30. The semiconductor according to claim 26 wherein the etched material is part of a photonic crystal structure as Photonic Crystal Distributed Feedback Laser or alike.
31. The semiconductor according to claim 26 wherein the etched material is part of an optical sensor.